THE ROLE OF CRUSTACEANS IN NITROGEN RECYCLING IN A HIGH ENERGY SURF ZONE ECOSYSTEM

The Sundays River surf zone (33°58'S,29°19'E) in the Eastern Cape South Africa is considered to function as a semi-closed ecosystem (McLachlan, 1980) with the outer boundary at the edge of the surf cell circulation pattern and the landward boundary at the drift line. Surf zones exist in three major energy states: a high energy dissipative state, a low energy reflective state, and a range of intermediate states (Short and Wright, 1983). The Sundays River surf zone exists in the intermediate longshore bar trough energy state for 90% of the year, moving to a high energy dissipative state during storms and to a lower energy intermediate transverse bar rip state during calm periods. The major mechanism for the return flow of water to the nearshore is via rip currents. Three types of rips operate in the surf zone: non exchange rips which do not break through the breaker line and serve to circulate water within the inner surf zone, exchange rips which carry water from the inner to the outer surf zone and mega rips which operate during storm conditions and discharge water kilometres out to sea. Half turnover time for water in the inner and whole surf zone is in the order of hours and days, respectively (Talbot, 1986). The unit of environment used in surf zone studies is a metre strip of surf zone from the drift line to the 10m depth contour 500m offshore which encloses a volume of 2500m^3 (McLachlan and Bate, 1984). Phytoplankton (mainly the diatom *Anaulus australis*) are the major primary producers in the surf zone forming dense accumulations usually in association with rip currents. Phytoplankton accumulations are a function of diel vertical migration patterns, offshore–onshore migration and the storm calm cycle. These phytoplankton accumulations fuel three distinct food chains: the macroscopic; interstitial; and microbial loop. The macroscopic food chain consists of benthos, zooplankton, fish and birds. Benthos form 46% of total macrofaunal biomass with filter feeding bivalves the most important component. Crustaceans (mainly the three spot swimming crab, *Ovalipes punctatus*) contribute only 1% of benthic biomass. Zooplankton are a major component of the macroscopic food chain forming 40% of macrofaunal biomass with numbers and biomass dominated by crustaceans. Small penaeid prawns (*Macropetasma africanus*) and mysids (*Mesopodopsis slabberi* and *Gastrosaccus psammodytes*) contribute >90% of zooplankton biomass (Romer, 1986). The role of crustaceans in the recycling of nitrogen in the Sundays River surf zone was determined from detailed laboratory and field studies on the nitrogen requirements of surf zone phytoplankton and the nitrogen dynamics of the major macrofaunal species. The nitrogen requirements of the surf zone were calculated directly from the estimates of phytoplankton primary production. Primary production was measured using C^{14} uptake and O^2 evolution. A mathematical model incorporating temperature, light, beach state, and photo-inhibition was used to estimate annual primary production. The portion of assimilated carbon involved in cell doubling was calculated and divided by the C:N ratio of *A. australis* (C:N ratio = 6.8). Using this method the nitrogen requirements of the surf zone (inner and outer) are calculated at 13,200 gN.m^{-1}.y^{-1}. (Campbell, 1987). The forms of nitrogen excreted and the effects of mass, temperature, starvation, diet and presence/absence of sediment on excretion rates were determined for *M. africanus* (Cockcroft and McLachlan, 1987) and the mysids *M. slabberi* and *G. psammodytes* (Cockcroft *et al.*, 1988). Information on population structure, abundance, diet and feeding behaviour collected over a decade of research in this area was combined with nitrogen excretion data to construct population nitrogen budgets for these species. The amounts of nitrogen recycled by the less abundant crustacean components (crabs and small zooplankton forms) were obtained from population nitrogen budgets using literature values for nitrogen excretion rates (Cockcroft, 1988). Crustaceans recycle 2626 gN.m^{-1}.y^{-1}. in dissolved inorganic form (mainly ammonia) which constitutes 79% of the dissolved inorganic nitrogen excreted by the macrofaunal food chain. Large zooplankton forms (prawns and mysids) supply the bulk of this recycled nitrogen. This represents 20% of total surf zone phytoplankton nitrogen requirements assuming that phytoplankton utilise dissolved inorganic nitrogen only. Crustaceans also contribute 1539 gN.m^{-1}.y^{-1}. or 64% of the dissolved and particulate organic nitrogen (mainly faeces) excreted by the macrofauna. This represents 17% of total nitrogen requirements estimated for the microbial loop (Romer and McGwynne, pers. comm.). Crustaceans therefore play an important role in surf zone nitrogen recycling both in terms of phytoplankton requirements and as a link between the macroscopic and microbial loop food chains.

Literature Cited

Campbell, E.E. 1987. 'The estimation of phytomass and primary production of a surf zone'. Ph.D. Thesis, University of Port Elizabeth. 330p.

Cockcroft, A.C. 1988. 'The role of macrofauna in nitrogen recycling in a high energy surf zone'. Ph.D. Thesis, University of Port Elizabeth. 285p.

Cockcroft, A.C. and McLachlan, A. 1987. Nitrogen regeneration by the surf zone penaeid prawn *Macropetasma africanus* (Balss). Marine Biology 96: 343–348.

Cockcroft, A.C., Webb, P. and Wooldridge, T. 1988. Nitrogen regeneration by two surf zone mysids, *Mesopodopsis slabberi* and *Gastrosaccus psammodytes*. Marine Biology 99: 75–82.

McLachlan, A. 1980. Exposed sandy beaches as semi-closed ecosystems. Marine Environmental Research. 4: 59–63.

McLachlan, A. and Bate, G. 1984. Carbon budget for a high energy surf zone. Vie Milieu 34: 67–77.

Romer, G.S. 1986. 'Faunal assemblages and food chains associated with surf zone phytoplankton blooms'. M.Sc. Thesis, University of Port Elizabeth. 194p.

Short, A. and Wright, L.D. 1983. Physical variability of sandy beaches. 133–144. In A. McLachlan and T. Erasmus (eds) 'Sandy beaches as ecosystems'. (Junk: The Hague).

Talbot, M.M.B. 1986. 'The distribution of the surf diatom *Anaulus birostratus* in relation to the nearshore circulation in an exposed beach/surfzone ecosystem'. Ph.D. Thesis, University of Port Elizabeth. 356 p.

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